there our party divided. Between Naples and Rome the communication was open, but, on arriving at Rome, we found very evident traces of the recent inundations, which are said to express the indignation of Providence or the delight of Father Tiber at the downfall of the Pope's temporal power. The regular route from Rome to Florence *viâ* Foligno and Perugia, was no longer available, as the flood had carried away most of the bridges on the railway, so we were compelled to take the other and very circuitous route *viâ* Civita Vecchia, Pisa, and Empoli. From Florence, after a delay of two days, during which large quantities of snow fell, we made an attempt to reach Bologna on January 9th, but our ill-luck still followed us, and we had to return whence we had come.

By the advice of some Italian friends, we decided to wait a few days at Florence before making a second attempt to cross the Apennines. Luckily we succeeded the next time in crossing the mountains and leaving Lombardy without any great inconvenience, for by this time the four feet of snow which had covered the country everywhere had been cleared from the rails. We experienced no further difficulty until we arrived at Brenner, where, after remonstrances on our part, we were turned out in a heavy snowstorm to find our way as best we could to the nearest hotel. The next morning we found that the cause of the delay was an avalanche, which, descending a very short time before our train came up, and carrying with it in its downward course trees and rocks, had effectually blocked up the line of rails. Vague rumours reached the hotel that no trains would pass for a week, that two battalions of Austrian soldiers were cutting a way through the snow, and that the avalanche was 200 yards in length, 80 feet in height, and extending across the gorge from side to side. We had no means of verifying these statements, as the telegraph wires were broken, and the officials were evidently as much in the dark as ourselves. Twenty-four hours after us the train bearing the Indian mails from Brindisi came up to the same spot, the passengers were treated as we had been, and ordered to turn out at midnight in happy ignorance of the cause of the delay. The mails were, however, sent up as near as possible to the obstruction, and thence carried over the tops of the mountains for a distance of eight miles, to a train which was waiting on the further side. The cold was intense at Brenner, and the depth of the snow confined us to the hotel. The weather, however, was only such as might be expected on the Alps, but we had good reason to fear from famine, as each successive train brought up regularly from Verona its freight of passengers, and discharged them all at Brenner, until the two hotels were full and overflowing. On the evening of the third day, as we sat at dinner, tidings came that the line was once more clear, and that a train would probably start that evening for Munich; so, thankful to quit the dull monotony of Brenner, we left by the night train, and after a delay of two days in passing through the disturbed parts of Germany, we arrived safely in England, having spent eight days *en route* from Florence.

W. A. HARRIS

St. Michael's Mount

IN the last number of NATURE there appears a letter from Mr. R. A. Peacock, of Jersey, in which he attempts to prove that St. Michael's Mount, in Cornwall, was insulated in the eleventh century. To do this, he quotes the passage from Domesday relating to the lands held by the church of St. Michael, which he translates—"Keiwal holds the church of St. Michael," &c. Now this land, Mr. Peacock says, was 240 acres, but the area of the Mount is now only 30 acres, so that there are 210 acres missing, therefore it could not at that time have been an island, because, in the eleventh century, it contained at least eight times as much land as it does at present.

Unfortunately for this theory, the passage which Mr. Peacock translates "Keiwal holds the church of St. Michael" is really "The church of St. Michael holds Treiwal, or Treuthal," as it is called on p. 11, which is a manor in the parish of St. Hillary, Cornwall.

H. MICHELL WHITLEY

Penarth, Truro, Feb. 6

The Zodiacal Light

IN NATURE for January 26, in the course of an interesting account of the Augusta Eclipse Expedition, by Prof. W. G. Adams, of King's College, there is a short allusion to the Zodiacal Light, which can hardly fail to be looked on by many as being, both on account of the author and the occasion, authoritative as well as important and instructive:—"At about $6^h\ 30^m$ on Monday evening (runs the article in question) we saw a brilliant display of the zodiacal light, consisting of brilliant pink streamers, stretching perpendicularly to the horizon, the planet Jupiter being just on the most brilliant streamers. Towards the north and round the horizon there were also streamers," &c.

Until assured by the author that the word "zodiacal" is not a misprint from something else, it is hardly worth while for me to point out in detail that the above description mentions almost everything which does *not* belong to the true zodiacal light, and nothing which does belong to or characterise it as hitherto known amongst astronomers.

C. PIAZZI SMYTH

15, R. Terrace, Edinburgh, Feb. 1

The Reign of Law

THE following is an extract from a letter I lately received from a friend of mine who is on the Geological Survey of India:—

"The Duke of Argyll and his Council have determined that the leave-rules, which are good enough for the natives, are good enough for us, although they are not sufficiently good for educated Europeans, such as the Staff Corps and Civil Service, and this they have resolved on, in spite of the Indian Government. If we could only get fair leave and pension rules, the same as men of the same rank and education receive in the other services, I do not think I should be tempted to give up field-work."

May I be allowed to inquire whether this is a new illustration of "The Reign of Law?"

TANTALUS

Misadventures in Conchology

MY experience seems to me curious; is it unique? I don't complain, I simply inquire.

1. As channel of communication for a foreign friend, I sent copies of his valuable conchological work to three public libraries in Great Britain. I know they were received. They have never been acknowledged.

2. I sent a complete set of shells, of a specially interesting field, to a foreign collection; they were delivered by a friend. They have never been acknowledged.

3. I sent (at his request) to a man of science a number of the rarer shells of a district. He acknowledged them through his clerk.

4. To a dealer at his urgent request and offer of exchanges, I sent a quantity (some hundreds) of shells. He sent me in return less than half what he had promised, selected from my list at his fancy.

5. To a scientific man in America, at his earnest request and offer of exchange, I sent a set of the shells of a district. No answer whatever.

6. I sent a unique specimen of a shell to a foreign conchologist for examination. I have never heard more of it.

7. At the earnest request of a dealer offering exchange, my brother sent a great number of Scotch glacial shells. His letter of request for desiderata was returned unopened.

8. A friend near me has more than once sent shells to German collectors, but has the same sad tale of packets sent, and no promised returns made.

Are these experiences exceptional, or is conchology fatal to conscience, or are *all* men liars?

VALLE

ON THE NATURAL LAWS OF MUSCULAR EXERTION

II.

HAVING shown[*] that Mr. Jevons' first and third sets of experiments illustrate laws 1 and 2 of muscular action, it remains for me to apply the same laws to his second set of experiments, and to show that they also illustrate these laws.

Before doing so, a few words may be said on the subject of the *maximum* of useful effect. I have shown, from theory, that a *maximum* of useful effect is obtained in holding out weights horizontally in the hand, by using a weight which is 73 per cent. of the weight of the arm

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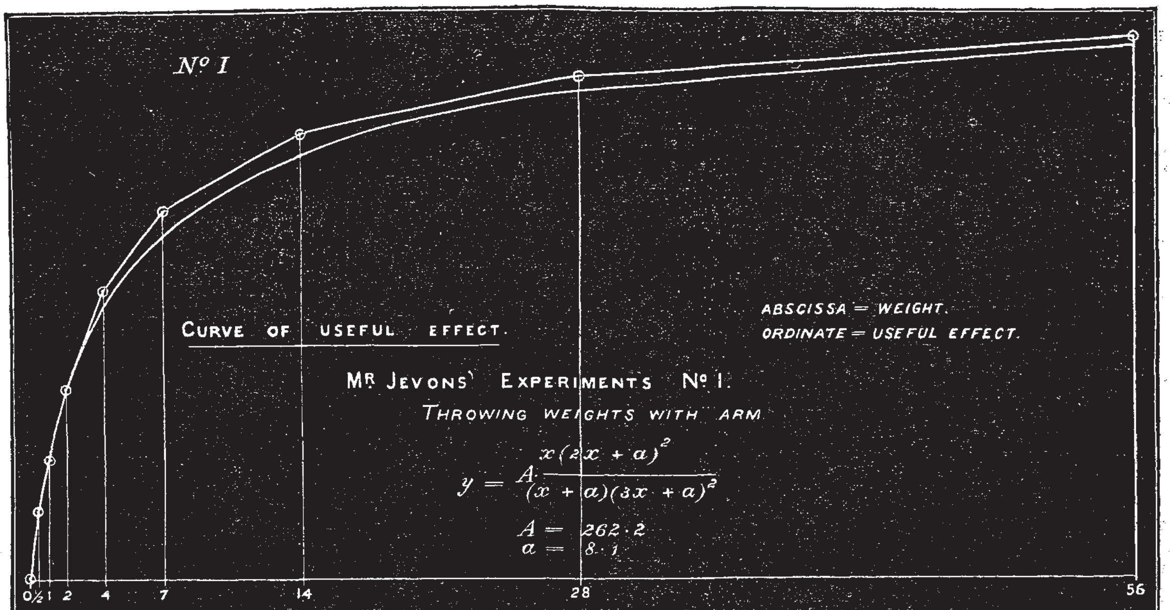
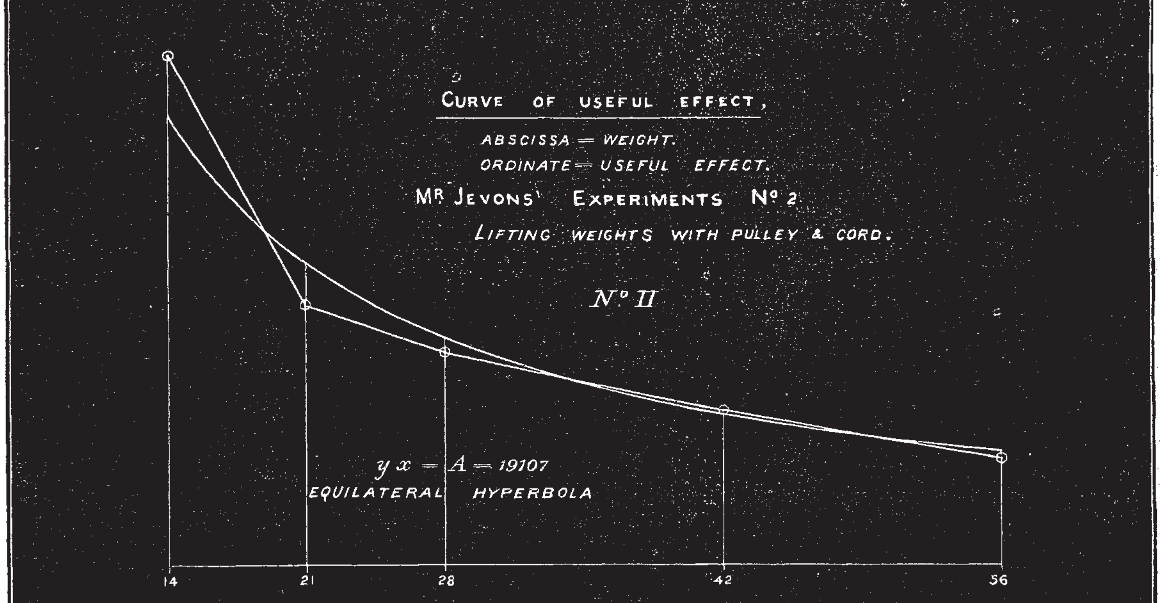
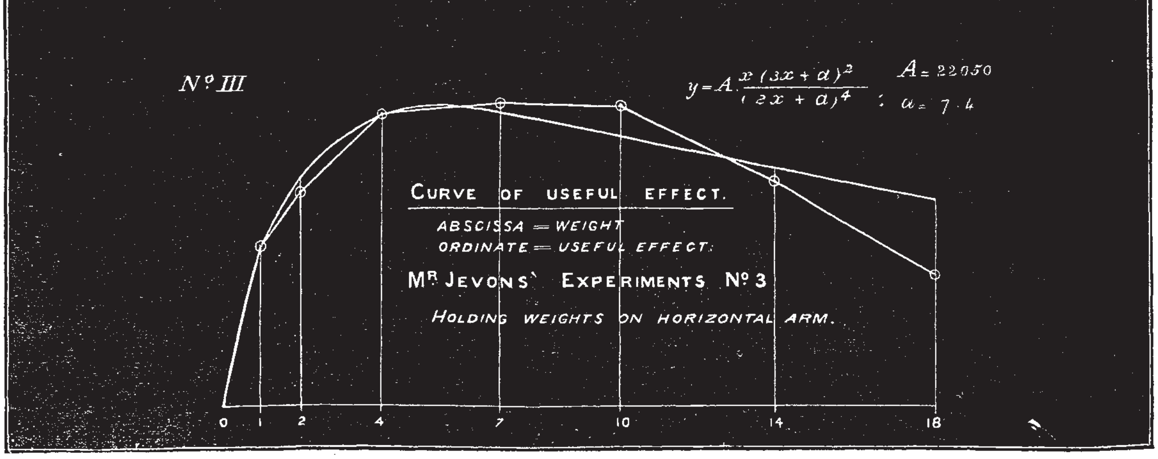
[*] See NATURE, vol. ii. p. 324.


No I
CURVE OF USEFUL EFFECT.
ABSCISSA = WEIGHT.
ORDINATE = USEFUL EFFECT.
MR JEVONS' EXPERIMENTS No 1.
THROWING WEIGHTS WITH ARM
$y = A \cdot \frac{x(2x+a)^2}{(x+a)(3x+a)^2}$
$A = 262 \cdot 2$
$a = 8 \cdot 1$
0 ½ 1 2 4 7 14 28 56


CURVE OF USEFUL EFFECT,
ABSCISSA = WEIGHT.
ORDINATE = USEFUL EFFECT.
MR JEVONS' EXPERIMENTS No 2
LIFTING WEIGHTS WITH PULLEY & CORD.
No II
$y x = A = 19107$
EQUILATERAL HYPERBOLA
14 21 28 42 56


No III
$y = A \cdot \frac{x(3x+a)^2}{(2x+a)^4}$; $A = 22050$; $a = 7 \cdot 4$
CURVE OF USEFUL EFFECT.
ABSCISSA = WEIGHT
ORDINATE = USEFUL EFFECT.
MR JEVONS' EXPERIMENTS No 3
HOLDING WEIGHTS ON HORIZONTAL ARM.
0 1 2 4 7 10 14 18

itself, and this result agrees with the experiments. In throwing weights with the arm Mr. Jevons found that there was no true maximum of useful effect, and that it increases with the weight used.

It can be shown from the equations used by me, which are deduced from Law 1, that this result might have been predicted from theory.

The useful effect is proportional to

$$w \times R,$$

or to

$$w \times V^2,$$

which, by equation (2), becomes

$$w \times \frac{a^2}{l^2} v^2;$$

this expression varies as the following, by equation (3)

$$w \times \frac{(2w + x)^2}{(3w + x)^2} v^2;$$

and since, by equation (1) or Law 1, v^2 varies inversely as $w + x$; we obtain finally

$$\text{useful effect} = \frac{Aw\,(2w + x)^2}{(w + x)\,(3w + x)^2} \tag{13}$$

The condition necessary to make this expression a maximum is

$$\begin{aligned} w\,(2w + x)\,(9w + 7x) \\ = (w + x)\,(3w + x)\,(6w + x); \end{aligned}$$

which reduces to the quadratic equation

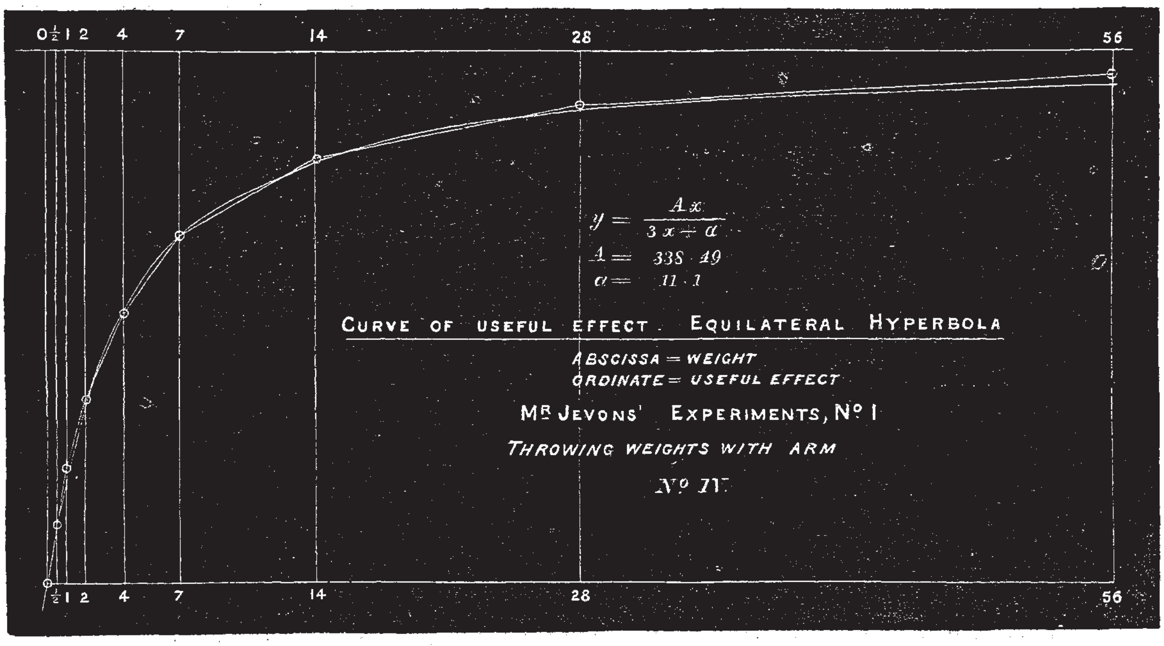
$$4w^2 + 3xw + x^2 = 0 \tag{14}$$

This equation has imaginary roots, viz.:

$$w = x\left(\frac{-3 \pm \sqrt{-7}}{8}\right)$$

Hence there exists no real value for the weight thrown which will make the *useful effect* a maximum.

Mr. Jevons' second set of experiments consisted in raising and lowering various weights by a pulley and cord, through the convenient range of the arm, and noting the number of times the weights were raised, the rapidity of the motion being maintained constant.



The results of these experiments are

Weight.	No. of times raised.
56 lbs.	5·7
42 „	11·9
28 „	23·0
21 „	37·6
14 „	110·0

It is easy to see, on theoretical grounds, that the weight (x) of the arm will disappear from the equations that represent the work done in these experiments; for in raising the weights the work done is proportional to

$$(w - x)\,n,$$

and in lowering the weights the work done is

$$x\,n.$$

These two, added together, give for the total

$$\text{Work done} = w\,n.$$

I have verified this anticipation of theory by introducing x into the *ten* equations furnished by the *five* simultaneous values of w and n, and I find that the mean value of x turns out to be

$$x = 0{\cdot}181\text{b.},$$

a value which, if the experiments were absolutely accurate, ought to become zero.

The rate of work is proportional to w, and multiplying this by the work done, in accordance with Law 2, we find

$$w^2 n = A \tag{15}$$

This equation gives the following values of A, corresponding to the five simultaneous values of w and n:

A	w
17875	56 lbs.
20992	42 „
18074	28 „
16582	21 „
21560	14 „

The mean of these values is

$$A = 19017.$$

Solving equation (15) for n, we find

$$n = \frac{A}{w^2}. \tag{16}$$

Substituting for A and w, in this equation, we find the following comparison of theory and observation :

w	n (observed).	n (calculated).	Difference.
56 lbs.	5·7	6·0	$-$ 0·3 $(\frac{1}{19})$
42 „	11·9	10·8	$+$ 1·1 $(\frac{1}{11})$
28 „	23·0	24·2	$-$ 1·2 $(\frac{1}{19})$
21 „	37·4	43·1	$-$ 5·5 $(\frac{1}{7})$
14 „	110·0	97·0	$+$13·0 $(\frac{1}{9})$

This table is satisfactory, as the differences are less than possible errors of observation.

The *useful* effect admits of no maximum in these experiments ; for it is represented by wn, and

$$w \times wn = A\,;$$

therefore—

$$wn = \frac{A}{w}\,; \qquad (17)$$

which represents an equilateral hyperbola ; wn becoming infinite when the weight is zero.

The agreement between Laws 1 and 2 and Mr. Jevons' experiments, may be best shown by means of the accompanying tables and diagrams, which represent the curves of useful effect, calculated from Laws 1 and 2.

FIRST SET OF EXPERIMENTS.

Throwing weights.—It follows from equation (5) that the useful effect

$$= wR = A\,\frac{w\,(2\,w + x)^2}{(w + x)\,(3\,w + x)^2} \qquad (18)$$

Substituting in this equation, the values

$$A = 262{\cdot}2$$
$$x = \quad 8{\cdot}1$$

we obtain the following table :—

USEFUL EFFECT No. 1.

w	wR (observed).	wR (calculated).
0	0	0
$\frac{1}{2}$	13·2	13·6
1	23·6	23·8
2	39·2	38·2
4	58·6	55·6
7	74·3	70·1
14	90·4	86·4
28	101·6	98·5
56	108·1	106·5

In the accompanying curve No. 1, the abscissa is the weight, and the ordinate the useful effect ; and the centres of the small circles represent the actual observations.

SECOND SET OF EXPERIMENTS.

Lifting weight with pulley and cord.—In these experiments the useful effect wn may be at once calculated from equation (17), from which the following comparison is made, and Diagram No. 2 constructed.

Substituting for A, its value 19,017, we find—

USEFUL EFFECT No. 2

w	wn (observed).	wn (calculated).
14 lbs.	1554	1358
21 „	790	905
28 „	644	679
42 „	500	453
56 „	319	340

The curve represented in Diagram 2 is a portion of an equilateral hyperbola, whose abscissa is the weight, and its ordinate the useful effect.

THIRD SET OF EXPERIMENTS.

Holding weights on hand extended horizontally.—The useful effect in these experiments may be calculated from equation (11).

$$\text{Useful effect} = wt = A\,\frac{w\,(3w + x)^2}{(2w + x)^4}. \qquad (11)$$

Substituting for A and x their values

$$A = 22050$$
$$x = \quad 7{\cdot}4$$

we obtain the following comparison, and construct Diagram No. 3.

USEFUL EFFECT No. 3.

w	wt (observed).	wt (calculated).
0	0	0
1	321	306
2	438	468
4	592	590
7	612	594
10	603	547
14	455	479
18	266	421

In Diagram No. 3, as before, the abscissa of the curve represents the weight, and the ordinate denotes the useful effect.

The equations of the three curves which represent the useful effect in Mr. Jevons' three sets of experiments, when expressed in Cartesian co-ordinates, are as follows :—

$$y = A.\frac{x\,(2x + a)^2}{(x + a)\,(3x + a)^2} \qquad \text{No. 1}$$

$$y\,x = A \qquad \text{No. 2}$$

$$y = A\,\frac{x\,(3x + a)^2}{(2x + a)^4} \qquad \text{No. 3}$$

It will be interesting, in conclusion, to explain why the simpler empirical formula, used by Mr. Jevons, coincides so nearly with the more complex formula deduced from theory.

According to Mr. Jevons' empirical formula, the useful work done in throwing weights is

$$\frac{B\,w}{2w + x}$$

where B = 231·4 ; and, according to my formula, deduced from theory, the useful work is

$$\frac{Aw\,(2w + x)^2}{(w + x)\,(3w + x)^2}$$

where A = 262·2.

These two expressions, algebraically considered, can never become identical, but may become nearly so, if

$$(w + x)\,(3w + x)^2 = K\,(2w + x)^3, \qquad (19)$$

in which K is a co-efficient nearly constant.

Expanding both sides we have

$$9\,w^3 + 15\,x\,w^2 + 7\,x^2\,w + x^3$$
$$= K\,(8\,w^3 + 12\,x\,w^2 + 6\,x^2\,w + x^3)\,;$$

from which we obtain four equations to determine the best value of K, viz. :—

$$9 = 8\,K \qquad K = 1{\cdot}125$$
$$15 = 12\,K \qquad K = 1{\cdot}250$$
$$7 = 6\,K \qquad K = 1{\cdot}166$$
$$1 = K \qquad K = 1{\cdot}000$$

Mean . . 1·135

The co-efficients of the two sides of equation (19) will be most nearly equal, when $K = 1{\cdot}135$.

The constants used by Mr. Jevons and myself give

$$K = \frac{A}{B} = \frac{2622}{2314} = 1{\cdot}133,$$

which is about the value required by the preceding considerations.

The curve denoted by Mr. Jevons' equation is an equilateral hyperbola, the co-ordinates being parallel to the asymptotes, and the origin taken upon the curve itself.

It is easy to see, from an inspection of Diagram No. 1, that a portion of such an equilateral hyperbola would coincide nearly with the true curve, and with the points determined by experiment.

Addendum.—Mr. Robert B. Hayward, of Harrow, has kindly called my attention to an error in my application of Law 1 to Mr. Jevons' first series of experiments in which different weights were thrown by hand. In applying Law 1 to these experiments, I assumed, in equations (1, 2, 3, 4), that the total work stored up in a revolving body is that of a body of equal weight, moving with the velocity of the centre of *oscillation*. I should have stated that it is the work of a body of equal weight moving with the velocity of the centre of *gyration*. If this error be corrected, the four equations become much simpler in form, and lead directly to the empirical formula used by Mr. Jevons, and also furnish a curve which corresponds very well with the experiments.

Let k denote the radius of gyration, and let the other symbols remain as before; we find the following equations, which are to be used instead of the first four already given.

$$(w + x)\, v^2 = \text{Const.} \tag{1}$$

$$v = V \frac{k}{a} \tag{2}$$

$$\frac{k^2}{a^2} = \frac{1}{3} \cdot \frac{3w + x}{w + x} \tag{3}$$

$$(3w + x) \times R = A \tag{4}$$

Mr. Jevons' eight experiments furnish twenty-eight equations to determine the value of x, and the mean of all the values is

$$x = 11{\cdot}1\text{lb.}$$

This value of x, when substituted in the eight equations furnished by (4), gives us the following values of A.

w	A
56 lbs.	329·5
28 „	351·8
14 „	364·2
7 „	338·9
4 „	337·5
2 „	318·9
1 „	325·0
½ „	342·1
Mean	338·49

If the mean values of A and x be used in equation (4), we find the following comparison of theory and observation:—

w	R (*observed*).	R (*calculated*).	*Difference.*
56 lbs.	1·84 feet	1·89 feet	−0·05 feet
28 „	3·70 „	3·56 „	+0·14 „
14 „	6·86 „	6·37 „	+0·49 „
7 „	10·56 „	10·55 „	+0·01 „
4 „	14·61 „	14·65 „	−0·04 „
2 „	18·65 „	19·79 „	−1·14 „
1 „	23·05 „	24·01 „	−0·96 „
½ „	27·15 „	26·86 „	+0·29 „

The curve of useful effect, deduced from equation (4) is

$$wR = \frac{Aw}{3w + x}.$$

This curve represents an equilateral hyperbola, whose equation, referred to its asymptotes as axes of co-ordinates, is

$$xy + 417{\cdot}4 = 0.$$

Diagram No. 4 shows this hyperbola, while the centres of the little circles show the several experiments.

This hyperbola, derived from the property of the centre of gyration, represents the observations very well; and it nearly coincides with the more complex curve derived from the centre of oscillation, shown in Diagram No. 1.

Mr. Jevons' empirical formula corresponds at once to equation (4), provided the quantity (q) be used to denote *one-third* of the weight of the arm instead of *one half*. His formula becomes, multiplying above and below by 3,

$$R = \frac{347{\cdot}1}{3w + 11{\cdot}7}$$

The weight of the arm and shoulder used in throwing weights, viz. 11·1lb. or 11·7lb., is considerably greater than the weight of the simple arm, 7·4lb., a result quite consistent with the fact that the scapular muscles move with the arm in this kind of exertion.

S. HAUGHTON

NOTES

AT a preliminary meeting held at King's College on Monday last, the Rev. Dr. Barry, Principal, in the chair, it was resolved that a fund for a Memorial to the late Dr. Miller, in connection with King's College as having been for thirty years the principal sphere of his labours, be at once raised by subscriptions in the College, and from the general public. It was further resolved to form a committee for the purpose of carrying out this resolution, and as soon as the committee is complete a meeting will be summoned to adopt such further measures as are necessary.

WE are glad to hear that Prof. Frankland has accepted the Presidency of the Chemical Society for the ensuing session.

A CIRCULAR has been issued by the Science and Art Department of the Committee of Council on Education, South Kensington, directing that in future all teachers certificated by the Education Department shall be allowed to earn payments on the results of the instruction of their pupils in Stage I. of Mathematics, according to the rules of the Science Directory, without having previously passed the qualifying examination required by § XXXIII. The Department has also issued the following amended programme of the examinations for the diplomas of the Royal School of Naval Architecture and Marine Engineering, which is to come into force at the examination to be held in April 1872, the examination in April 1871, being held according to the programme contained in the existing Directory of the School:—"Diplomas will be given to all persons, whether they have received their instruction at the school or not, who pass the final examinations of the school, provided that they give satisfactory evidence of having gone through the course of practical work recommended by the Council of the Institution of Naval Architects. These diplomas will be of two grades, according to the success of the candidate in the examination, the title of the higher grade being Fellow, and of the lower, Associate, of the Royal School of Naval Architecture." These examinations will be held annually towards the end of April. Candidates who have not been students of the school will be required to produce certificates that they have been engaged for three years, at least, in—(1) practical wood or iron ship-building in a dockyard; or (2) practical engine and boiler building in a dockyard, or in the works of a marine engineer; or (3) practical work as a draughtsman in a dockyard (or marine engine works), during which the candidate must have himself gone through the complete formation of the design of a ship (or of a marine engine), with the whole of the calculations included in it. Such candidates will also be required to give references as to character and good conduct before they are admitted to the examination. All such candidates must apply to the Secretary, Science and Art Department, South Kensington, W., not later than the 15th March in each year.

IN our notice last week of the attainments of the Senior Wrangler, we should have included the statement which we made some time since, that Mr. Hopkinson took the degree of D.Sc. at the Uni-